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THE MINIATURE PIG: A BIOMEDICAL MODEL FOR BEHAVIORAL STUDIES

R. L. Chaput
E. L. Barron
J. K. Warrenfeltz
W. W. Wolfe
T. K. Dalton

ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
Defense Nuclear Agency
Bethesda, Maryland

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R. L. CHAPUT
E. L. BARRON
J. K. WARRENFELTZ
W. W. WOLFE
T. K. DALTON

Joe E. West
JOE E. WEST
Lieutenant Colonel, USAF, VC
Chairman
Radiation Biology Department

Myron I. Varon
MYRON I. VARON
Captain MC USN
Director

ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
Defense Nuclear Agency
Bethesda, Maryland

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TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Procedures for training pigs by shock avoidance conditioning to perform a shuttlebox and a visual discrimination problem are described. Pigs achieved stable performance levels of better than 95 percent shock avoidance in 6 and 35 days for the shuttlebox and discrimination problem, respectively. Such stable and accurate performances are required for assessing behavioral effects of independent variables.

I. INTRODUCTION

Physiologically and structurally, the miniature pig is, in many respects, similar to man and has served as an extremely useful model in many biomedical research programs.[1,2] Pig behavior, however, has not been extensively studied, and relatively little information is available on their learning ability. Little is also known concerning tasks most suitable for evaluating the performance capabilities of these animals.

Standard swine have been shown to be able learners after both classical[9-12] and operant[5-8,13,14] conditioning. However, except for the work of Karas et al.[5] and Kratzer,[8] the procedures used in most of these studies are not amenable for testing large numbers of animals, for rapid presentation of trials or for measuring transient behavioral deficits. All are necessary requirements when evaluating postirradiation performance. In addition, radiation causes inappetence, thus, food reward was precluded and electric shock avoidance techniques were required.

A simple two-chambered shuttlebox problem similar to that of Karas et al.[5] was developed for the initial studies. To better identify subtle effects and to compare the differential effects of the treatments on pigs performing tasks requiring varying degrees of motor coordination and cognitive abilities, a visual discrimination problem was also developed.

II. MATERIALS AND METHODS

The experimental animals were 51 miniature pigs of the Hormel and Hormel-Hanford strains. They were 3 to 6 months old when their training began. As no significant sex-related differences in learning ability were found in preliminary studies, males, females, and barrows were randomly selected for the definitive investigations.

A two-chambered shuttlebox was designed for training and testing (Figure 1). A guillotine-type door, operated by air pressure, separated the two chambers.

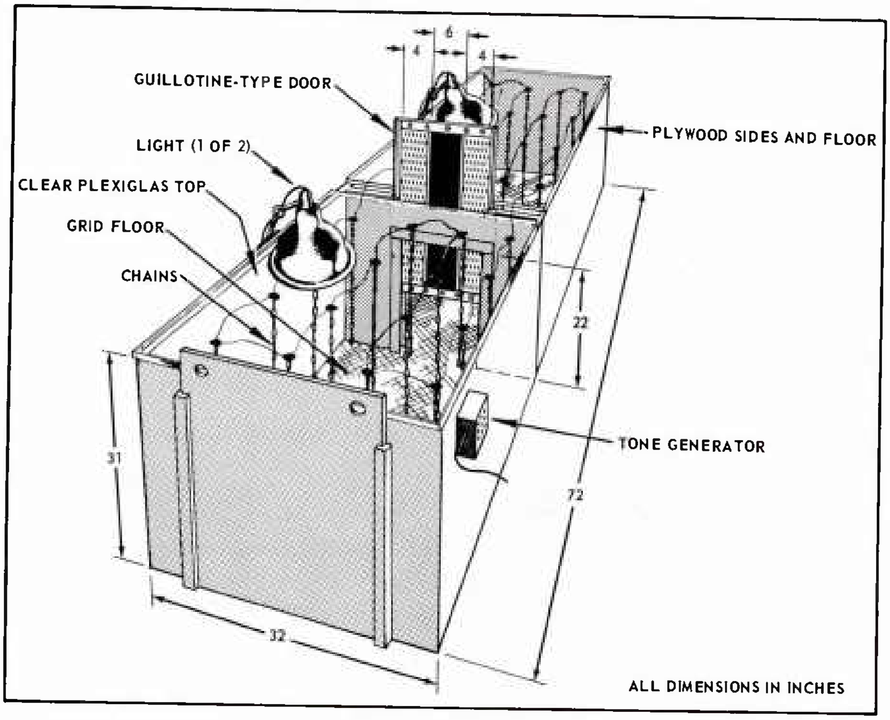

Figure 1. Shuttlebox

Tungsten lights (150 watts), a tone (1000 Hz), and the raised guillotine door served as the conditioning stimuli (CS) and were alternated such that the pig had to move through the opened door toward the lighted chamber and away from the darkened chamber. A 60-cycle electrical current, adjusted between 0 and 10 mA with a maximum of 170 V, applied through chains hanging from the top of the box to within 1 inch of the grid floor served as the unconditioned stimulus (US). The shock was carefully controlled to ensure that only the minimally required level needed to stimulate the appropriate response was administered. To ensure contact with the chains, the hair was clipped from the dorsal and lateral surfaces of each pig.

Twenty-five pigs were trained by shock avoidance conditioning to cross the shuttlebox. Each 13-second trial consisted of a 6-second period when the CS alone were presented, a 4-second period when both CS and US were given, and a 3-second rest period. To avoid shock, the pig had to move from the darkened chamber to the illuminated chamber during the 6-second CS period. Upon crossing the box, the pig was credited with an avoidance, the CS were turned off and a rest period was given for the remainder of the trial. If the pig did not cross the box until the shock was applied, it was credited with an escape and again a rest period was given for the balance of the trial. An omission was scored if the pig did not cross the box during the 10-second testing period.

On the first day of training the pigs were placed in the shuttlebox and given a few minutes to acclimate. When accustomed to the shuttlebox, the CS were given for the usual 6 seconds before applying electrical shock. The shock was then given in brief, manually controlled pulses to prompt the pigs to cross the shuttlebox. Shock was terminated when the animal either succeeded in crossing or became excited. If the latter occurred, a rest period was given before training was resumed. The animals usually learned to escape shock after less than 10-20 trials. After this brief shaping of the animal's response, the presentation of the CS and US as well as the recycling of each 13-second trial was controlled by preprogrammed electronic timers. However, a given trial was terminated and a rest period started by the observer manually depressing a stop button when the pig crossed the box. The time from the beginning of the presentation of the CS to the crossing of the box was automatically recorded to the nearest 0.01 second for each trial. The pigs were trained or tested for about 15 minutes each day and were given 20 to 30 trials in sets of 10 each during training and testing. Except for the 1st day, shuttlebox training was almost entirely experimenter independent.

The visual discrimination chamber shown in Figure 2 was designed for training and testing the ability of pigs to touch the brighter of two lighted panels with their snouts. The CS consisted of the two lighted panels, initiating a tone (1000 Hz) and extinguishing the chamber light (tungsten lamp, 150 watts). The intensities of the panels at a distance of 1 foot were 32 and 16 foot-candles for the bright and dim panels respectively. The relative intensity of the lights behind the panels was randomly switched from one trial to the next. Electrical shock, delivered as described for the shuttlebox, served as the US.

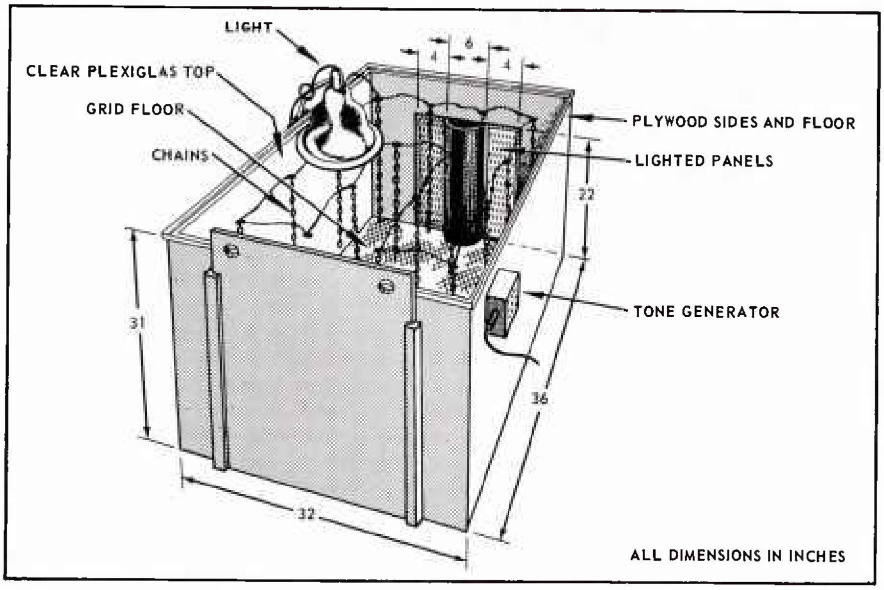

Figure 2. Discrimination chamber

Twenty-six pigs were trained to work the visual discrimination problem. All animals were first trained to the shuttlebox problem as it proved a convenient method of introducing brightness as a positive stimulus. The guillotine door of the shuttlebox was designed to appear similar to the panels of the visual discrimination chamber. Once trained to the shuttlebox problem, the animals were transferred to the discrimination chamber and trained by shock avoidance conditioning to touch the brighter panel with their snouts. The similarity of the shuttlebox door and the panels of the discrimination chamber was found to accelerate the transition between the respective problems.

Each trial lasted 10 seconds and consisted of a 6-second test period during which the CS were presented (chamber light off, panel lights and tone on) and a 4-second rest period during which the CS were off (chamber light on, panel lights and tone off). If the pig touched the brighter panel (correct response) during the test period, a rest period was given for the balance of the trial. If the animal touched the dim panel (incorrect response) or did not touch either panel (omission) during the test period, a 1/2-second electrical shock was delivered immediately before the rest period.

The entire process of recycling the trials and presentation of the various stimuli was controlled automatically by preprogrammed timers and the response of the pigs was sensed by proximity detectors attached to the panels. The time from the beginning of the presentation of the CS until the pig touched a panel was recorded to the nearest 0.01 second for each trial. During daily training and testing sessions of 1 hour each, the pigs were given a total of 300 trials presented in sets of 100 each.

The first stages of discrimination training were also manually controlled by the experimenter. Initially only the panel having the brighter intensity was used. When the pig responded positively by approaching the lighted panel, the stimuli were terminated and the rest period given as positive reinforcement. As training proceeded, behavior was reinforced only when it more closely approximated the desired response, i.e., touching the panel with the snout. During this phase, switching of the light from one panel to the other was kept to a minimum until the animal had learned to touch the lighted panel. Thereafter, switching gradually became more random. When the pigs consistently touched the lighted panel (70-80 percent shock avoidance), the dim panel was then introduced and subsequent training was entirely automated.

III. RESULTS AND DISCUSSION

Figures 3 and 4 show the average levels of performance achieved by miniature pigs during training for the shuttlebox and visual discrimination tasks, respectively. Miniature pigs achieved an average steady-state performance level of 99.0 ± 0.09* percent shock avoidance at 6.3 ± 5.1* days for the shuttlebox task. For the visual discrimination task, pigs achieved 97.3 ± 1.7* percent correct responses at 34.5 ± 15.2* days, the latter period exclusive of preliminary shuttlebox training.

For either task, the decreased latency of response shown in Figures 3 and 4 correlated with the increased ability of the pigs to perform correctly and thus avoid electrical shock. When performing at steady-state levels, the pigs required, on the average, 2.10 ± 0.51* seconds to traverse the shuttlebox and 1.59 ± 0.76* seconds to touch the brighter panel. Response time did not appear to be a more sensitive indicator of performance than percent response since values for both parameters became

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* Standard deviation

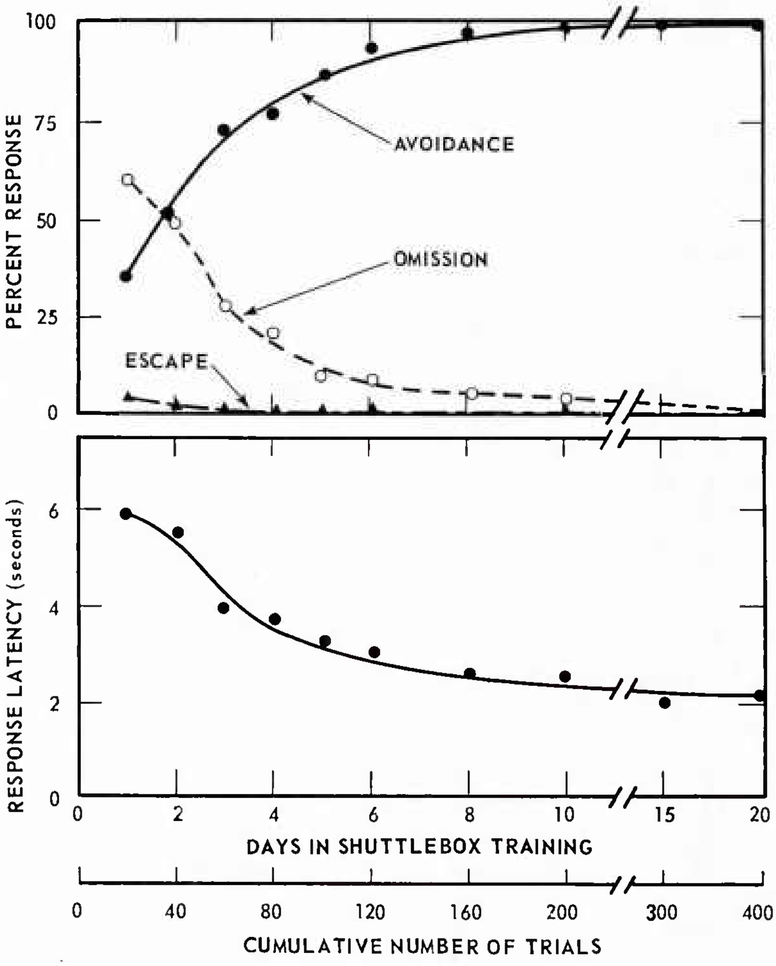

Figure 3. Miniature pig performance during shuttlebox training

asymptotic simultaneously. However, in behavioral studies these data should be obtained since previous work has shown this information can provide an additional estimate of performance efficiency.[4]

There was a remarkable similarity between the ability of the pigs to learn the two tasks. Except for the much longer time and greater number of trials required to learn the discrimination task, the transition from primarily omission to primarily

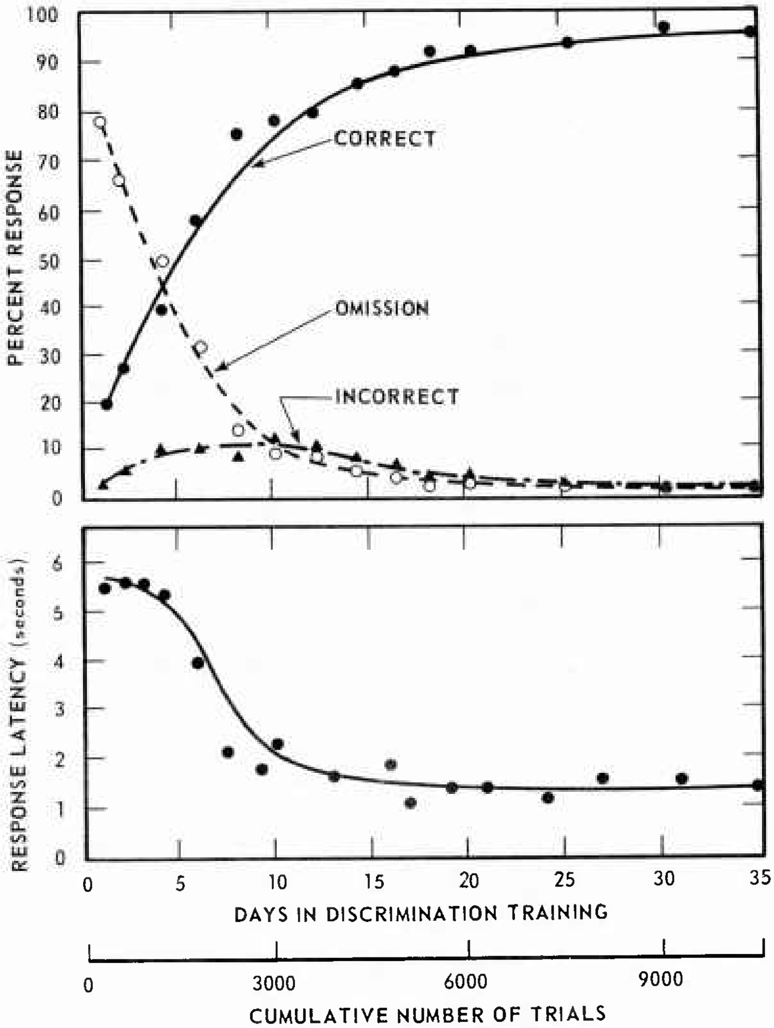

Figure 4. Miniature pig performance during discrimination training

shock avoidance responses was quite rapid, e.g., 4 and 10 days for the shuttlebox and discrimination task, respectively. The positive response of the pigs during the initial phases of training was highly sensitive to operator error (i.e., shock, inadvertently applied as the animal attempted to make a correct response, had a marked regressive effect on subsequent training).

The more extensive training program required for the visual discrimination task compared to the shuttlebox task suggests a definite cognitive difference between the two tasks. Several observations lend support to this conclusion. During discrimination training, pigs were more easily distracted than when learning the shuttlebox task. Further, after pigs received similar doses of ionizing radiation, performance of the visual discrimination task was more adversely affected than that of the shuttlebox task.[3] Thus miniature pigs trained to perform these tasks would appear to serve as a useful biomedical model for studying effects of a wide range of clinical and environmental stresses which may have behavioral consequences.

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